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ABSTRACT

The Zimbabwe Secondary School Science Project (ZIM-SCI) developed student study guides, corresponding teaching guides, and science kits for a low-cost science course which could be taught during the first 2 years of secondary school without the aid of qualified teachers and conventional laboratories. This teaching guide, designed to be read in conjunction with the related student guide, includes instructional strategies, lists of required materials, laboratory procedures, and other information for activities and experiments which introduce students to the idea of becoming a scientist. These activities and experiments (which focus on the need both for the five senses and for equipment to make measurements, and on the display of experimental results in graphic format) are designed to help students understand that measurements are never perfect, to recognize errors, and to judge how accurate their results might be. Each section in this guide corresponds to a given section in the student study guide. (JN)

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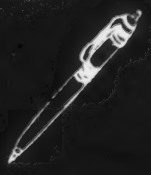
MARCH, 1981

BEST COPY

TEACHER'S GUIDE

In the guide to each lesson, symbols will be used to indicate t he point at which teacher activity might be needed. The symbols are as follows :-

Practical work. The necessary instructions for each experiment will be given to you when you see this symbol.



Written exercises for the pupils. If possible these should be put on the blackboard before practical work begins so that the pupils can see what to look for.

Teacher information. The pupils will need extra guidance at these points. The information they will need from you is given where you see this symbol.

These will appear at the same point in the study guide.

Take note of an important point.

This symbol indicates a preparation of apparatus which should be done well ahead of time. Please read these notes carefully and carry out the instructions well in advance.

TEACHER'S GUIDE

UNIT A1 : LEARNING TO BE A SCIENTIST

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AIMS UNIT A

(EXTRACTED FROM SYLLABUS)

LEARNING TO BE A SCIENTIST

At the end of this unit, pupils will be able to :-

1. list two ways in which our senses are inadequate
2. identify the correct type and size of instrument to use for a particular measurement of length, volume, mass, temperature or time
3. identify the scale divisions on a variety of measuring devices
4. read an instrument scale to the nearest division
5. demonstrate how to :
   (a) find the mass of a liquid in a container by difference;
   (b) measure the volume of a solid by displacement;
   (c) measure the thickness, volume and mass of one of many small objects by division
6. describe in writing the results observed after mixing several pairs of liquids and after performing some simple chemical reactions
7. demonstrate the technique for separating solids and liquids
8. tabulate a rough set of measurements in a form suitable for graphing
9. construct a histogram from a set of tabulated (ordered) results
10. deduce some tentative conclusions from experiments on simple scientific problems.

Teacher's Guide

Unit A1 - Learning to be a scientist

Welcome to the new Form I Zim-Sci course. We hope that you will enjoy teaching this course, and that the hints set out in the teacher's guides will be of use to you.

General hints about the course are contained in the TEACHER'S HANDBOOK. If you have not read this yet, we suggest you do so. Each teacher's guide is designed to be read together with the appropriate pupil study guide.

The first unit of the course is an introduction to the idea of being a scientist. The science of measurement, together with practical exercises, forms the main part of the unit. In the last section, graphical treatment of results is introduced.

Throughout the unit, the idea is stressed that measurements are never perfect. Pupils are encouraged to recognise errors and to judge how accurate their results might be. Please read through the whole lesson, which you intend to teach, well ahead of time, preparing in advance whatever is necessary. Things which we know will take a particularly long time to prepare are marked (P). Please read them at least the day before.

For example, in this unit, pupils will probably reach page 4 (ending with making ammonia) in the first lesson. Have ready all the chemicals and apparatus required to get to this point.

Do not try to rush the class. If they do not get as far as you think they will, that is not important. With your help and wise guidance they will learn that science is enjoyable and not difficult.

Good luck with your teaching!

Part 1 : Special Note

On page 19 of this guide you are asked to gather empty matchboxes. Please read this important note and tell the pupils about it so that they can gather the matchboxes soon.

Part 1 Page 2

Please read the introductory page aloud to the pupils. They will need your support and encouragement. Perhaps you could ask some of them what they imagine a scientist to look like at the end of the first paragraph before proceeding to paragraph 2.

Page 3 Basic Kit

Before reading the list of basic kit apparatus given below, please make sure that pupils have their large diagram FROM THE KIT in front of them. They should make a tick (✓) ON THE DIAGRAM as you call out the names, as soon as they have found the item required. It would help them to check easily if they take everything out of the box first, then put back the items one by one as you call. This will also teach them the names of the apparatus.

Items in the basic kit :

1 beaker	1 box matches
1 burner + extra cap with wick	1 spatula/stirrer
1 funnel	1 5 ml measure
2 plastic bottles	1 2 ml measure
1 peg	1 evaporating dish
1 stand	2 plastic cups with lids
1 boiling tin	

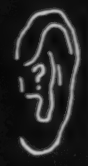
Pages 3 to 5 describe a series of small experiments which the pupils do. These experiments are designed to make the pupil aware of each of their five senses in turn.

The next sections 5 - 7 extend this awareness to include the limitation of each of the senses.

Page 3 Looking at the funnel

Main idea: the pupils should use only their fingers to get ideas about the funnel.

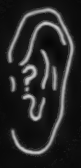
W hat follows is one way in which you might get this idea over to the pupils. We suggest you read this to the pupils as it will save time. When you feel you have more experience of the course you may like to express the main ideas in your own words.



"Both partners of a pair can feel the funnel together. Pick up the funnel and close your eyes. Try to get an idea of the funnel by feeling with your fingers. What can you feel? It is certainly smooth on the sides - feel the edges now. Are they smooth too? Can you feel the raised lines on the sides which help to hold the funnel steady and stop it slipping? Can you tell which way up the funnel is? Open your eyes now."

Page 4 Making banging sounds

You will need : conical flask
metre rule
boiling tin
ruler



Make the sound by tapping the ruler against :

1 . metre rule
2. conical flask
3. boiling tin

Tell the pupils to guess, calling the metre rule "Number 1", the flask "Number 2" and the boiling tin "Number 3".

They will have to write down their guesses in the exercise following this part of the lesson.

Page 4 Three dishes

In three evaporating tins (your own, plus two, borrowed from two pupils' boxes) put a small pile of

1. mealie meal
2. salt (sodium chloride)
3. sugar

The pupils must guess what they are.

Wash out the tins and dry them well when you have finished.

This is the first chemical experiment your pupils will do. Please follow the instructions carefully.

You will need :

1 . water in a clean bucket
2. your spatula/stirrer
3. ammonium nitrate (the pupils should be told : this is "Substance 1")
4. solution of sodium hydroxide (the pupils should be told : this is "Substance 2") which is made by you as follows:

N.B.

Into a conical flask put 5 spatulas sodium hydroxide pellets. CAUTION : DO NOT touch these pellets - they will burn your skin. If you should get some on your skin, wash IMMEDIATELY with plenty of cold water.

Add 150 ml cold water to the flask. Stir with your stirrer. It will take quite a time for the pellets to dissolve so you should prepare the solution <u>well ahead of time</u>.

P

When it has dissolved, WASH your spatula/stirrer well and dry it on your cloth. If any of the solution should spill on your skin, wash it off straight away.

Ask your pupils to bring up their beakers and their measures. Into each beaker, put 1 spatula ammonium nitrate. If they ask its name, it is all right to tell them but it is not <u>needed</u> at this point in the course.

Perhaps they can pour the sodium hydroxide solution into their 5 ml measure for themselves, or perhaps a dropper would help. Please use your judgment here. Wash off any spilt solution immediately. Do not forget to warn the pupils about this as well.

N. B.

WARN the pupils about smelling chemicals. The correct way (avoiding all danger to the nose) is to wave the hand across the top of the container until the small reaches the nose. They should NEVER put their noses right inside.

When they have smelt the ammonia coming off, they should throw away the contents of the beaker into the waste bucket and wash their apparatus WELL with clean water.

If they fail to detect ammonia, they can repeat the experiment and smell harder.

When they are settled again, please put Exercise 1 on the blackboard and tell them to answer it in their Exercise books. Throw away the remaining sodium hydroxide solution and wash the flask very well.

Exercise 1

1. The colour of the funnel was _____
2. Which felt more smooth, the sides of the funnel or the edges? _____
3. The first noise (No. 1) was caused by banging on _____
   No. 2 was _____
   No. 3 was _____
4. The three dishes tasted like
   1. _____
   2. _____
   3. _____
5. The gas that you smelt was _____
   Could you see the gas? Yes/No Have you ever smelt this before? Yes/No If so, where did you smell it?
   _____
   _____

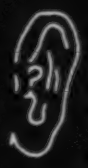
Answers (to assist you with your marking)

1. The funnels are many different colours. You will see this for yourself.
2. The sides should be smoother
3. 1) wood
   2) glass
   3) metal
4. 1) mealie meal
   2) salt
   3) sugar
5. Ammonia
   No, the gas cannot be seen.
   Possibly the pupils have smelt ammonia before e.g. in manure heaps.

Page 5 Can we trust our senses?

Don't forget to get out all the necessary apparatus well ahead of time!

Looking at the chart



The notes in the study guide are a brief outline of the sort of questions to ask on the optical illusions presented on the chart.

As before, you might like to read the following :

"Look at Picture 1. Who thinks that the top line is longer? Who thinks the bottom one? Who thinks they are the same length? Let us measure them to see.

They are both the same! So our eyes have played tricks on us! Now we shall look at Picture 2. Who is the tallest person? Who thinks the man in front? Who thinks the one in the middle? Who thinks the man at the back? Well, the man at the back certainly looks taller, because his head sticks up above the wall. But is he really bigger than the others? Let us measure again, from their heads to their shoes, and see whether the one at the back measures more.

No! They are in actual fact all drawn the same size. It is the wall at the back that makes us THINK that the back one is bigger.

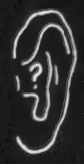
Now let us look at Picture 3: the man, the buck and the elephant. Who thinks the man is stabbing the buck? Who thinks the elephant? Well, it certainly looks as though the spear is close to the elephant, but we must realise that the elephant is far away. How do we know this? We know this because the elephant in the picture is very small but the man and the buck are big. An elephant as you know is really much bigger than a man or a buck. The man cannot spear the elephant because the elephant is far away on the hill. He is stabbing the buck!

What about Picture 4? Are lines A and B bent? Who thinks they bend? Let us see - someone should come up and put a ruler along them.

They are not bent! Once again we have a situation where our eyes play tricks.

Picture 5 shows a small white circle within another circle and a small black circle by itself. Which is bigger? Who thinks the white? Who thinks the black? Let someone else come and measure with my ruler.

Once more they are the same!



The last picture shows some black squares. Look hard at the squares. Who can see little black dots in the spaces between the squares? If you look at the spaces, the dots go away. If you look at the squares, they come back again!*

Now return to the study guide.

Page 6 Experiment 2 Feeling hot and cold

Before pupils come up to try this experiment you will have to heat up the water. It is probably easiest to use boiling tins (your own + 2 from pupils). Heat up the "hot" tin of water to about 70°C (just too hot to hold) the "warm" tin of water to about 45°C (pleasantly warm) and leave the last tin of water at room temperature.

The pupils should not take long to do this experiment. They can form a line and pass in front of the tins quite quickly. The water should feel cool to the "hot finger" (right hand) and warm to the "cold finger" (left hand). Try this for yourself ahead of time.

When the pupils have finished, throw away the water and THOROUGHLY DRY THE TINS using your drying cloth.

Page 6 Experiment 3 Using your nose

You will need : your boiling tin (dry)
your 5 ml measure
your spatula
ammonia solution (ammonium hydroxide)
naphthalene

Put 2 spatulas naphthalene into your boiling tin. Pass it round the class quickly for pupils to smell. Encourage them to smell in the correct way, by waving the smell towards them.

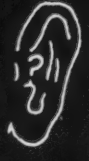
When the tin returns to you, pour in 10 ml ammonia solution (use your 5 ml measure twice). Pass it round again quickly. Check that the ammonia has not all gone away when the tin is about half way round the class. If it has, add another 5 ml ammonia solution.

Probably you will find that some pupils can still smell naphthalene, some only ammonia. A few may claim to smell both. It does not matter. The aim of the exercise is to show that confusion can exist when we use our sense of smell.

Throw away the chemicals and wash and dry the tin well when you have finished.

Page 7 Experiment 4 Using their ears

This experiment aims to show that the sense of hearing can be confused. The pupils should go outside and stand in pairs. One member of the pair should close his eyes, and shut one ear with his hand. The other should move around him silently and then clap. The one with eyes closed should try to point in the direction of the sound. After several claps, the pupils can change over.



The pupils will find that their sense of hearing will not be reliable. Some will be better than others at pointing in the right direction, but it should be quite clear that many mistakes are made. The pupils will enjoy this experiment as they will be fooling their friends. Let them do it several times if they want to.

Page 7 Experiment 5 Tasting orange juice

You will need :packet of orange juice crystals
conical flask - very clean!
stirrer
5 ml measure
tube of toothpaste
water

Make up the orange juice as follows :-
Take about one third of the packet of crystals. Put it into a CLEAN conical flask and add water to the 200 ml mark. Stir well.

I t is probably best to ask the pupils to bring up their clean plastic cups. There are enough cups to have one each. Pour out about 5 ml of orange juice into each plastic cup. They should each take a small sip from their cups and then take a little piece of toothpaste on their finger. They do not need a lot : a piece about 1 cm long is plenty. They should rub it round their teeth very well, front and back, before tasting the orange juice again.

The second time the pupils taste the orange juice it should taste horrible!!

All apparatus should be WASHED WELL afterwards.

Page 10 Experiment 6 Measuring length

Please have the two metre rules ready to pass round the class.

Write on the board questions 1 to 3 of Exercise 2. (The complete Exercise 2 is found on page 12 in this guide).

When the class has estimated the length of the wall you have chosen and all the guesses have been put on the black-board, please measure the wall accurately yourself. Make small pencil marks (or similar) to assist your measurement, and give the result to the nearest millimetre. (0,001 metres) For example, suppose you measure 5 metres 43 cm 6 mm. This is 5,436 m. Then your result is CORRECT TO THE NEAREST millimetre. It is correct to the THIRD DECIMAL PLACE.

Show the pupils that the metre rule is divided into milli-metres, and that the human eye cannot estimate better than about half of a division, or half a millimetre. Thus the error in the measurement is about half a millimetre because the eye cannot do any better.

Experiment 6 Measuring length

The purpose of this experiment is for pupils to gain the experience of measuring a length as accurately as the metre rule will allow. A second purpose is to help them become aware of the fact that even measuring accurately, several measurements always produces a range of results

Divide the class into two big groups. Five from each group should take it in turns to measure your desk. (Pupils from each group should measure opposite each other, on opposite sides of your desk). When they have an answer, they should whisper it to the writer, who will not allow anyone else to see until all are finished. The rest of the group can watch, and suggest improvements if they can. Maybe the desk could be marked with pencil or some such thing - it is up to them.

Put the ten results on the board. At this point your judgment will be needed, because it is not possible to predict how good the class results will be. Perhaps they will all be the same in the first decimal place as in the example in the study guide, but they might be better than that, and agree in the second decimal place also. Then the error is much smaller. You will have to guide them in the point of error, and estimate their "close to" answer from this. If their answers agree to the second decimal place, then this can be included in the "accurate answer".

The highest value obtained should be the answer recorded for "not more than ____" and the lowest value for "not less than____".

Write the rest of Exercise 2 on the board for the class to answer in their books. Please make sure that their work is done in a book, because the results from Unit A1 will be needed later on in the course.

Exercise 2

1. My estimate of the length of the wall is _____ metres.
2. My teacher's measurement is _____ metres.
3. It was correct to the nearest _____ metres.

THE ABOVE THREE QUESTIONS ARE WRITTEN ON THE BOARD AT THE BEGINNING OF THE SECTION ON LENGTH MEASUREMENT, THE OTHERS ON COMPLETION OF EXPERIMENT 6.

4. The class results for the measurement of the desk are

1. _____	6. _____
2. _____	7. _____
3. _____	8. _____
4. _____	9. _____
5. _____	10. _____

5. Our class measurement of the teacher's desk was close to _____ metres.
6. It was correct to the nearest _____ metres.
7. It was not more than _____ metres or less than _____ metres.

Answers : some hints

Question 1. No "correct answer". Any reasonable guess is acceptable.

Question 2. Given by you.

Question 3. Probably correct to nearest mm i.e. 0,001 m

Question 4. As measured.

Question 5. Discussed on page 10

Question 6. Discussed on page 11

Question 7. Discussed on page 11

Page 12 Measurement : Temperature

This experiment is to give the pupils experience in estimating temperature.

Please read carefully with the pupils the Introduction to Temperature from the study guide pages 11 - 12 while you are waiting for the water to boil.

You will need : bucket of water at about 45°C (pleasantly warm)

This will be a rather tedious job to prepare. It will be best to heat up three flasks of water to boiling at the same time then pour them into cold water already in the bucket. Check that the temperature is about 45°C. If it is not, add more hot or cold water as required. Of course i f you have a kettle or a handy kitchen the warm water will not be a problem! Make the bucket almost full.

While the pupils are guessing, put Exercise 3, Question 1 and 2 on the board. The complete Exercise 3 is found on page 15 of this guide.

Keep the bucket of water after the pupils have finished estimating its temperature Before you give them your reading put all the guesses on the board. You should check the temperature using a thermometer just before the pupils begin the experiment, and again when they have finished. Take the average of the two readings (they should not be very different) as "the teacher's reading" . Stir the bucket before taking each reading.

When they have finished the estimation, hand the thermometers out to the class. Make it clear to the pupils that these are very delicate, easily broken instruments and that they are expensive. They should never put them into their mouths.

14

Page 13 Meaning of the zero point on the thermometer

The main idea is that the zero point does not mean "no heat at all", but is a convenient point from which to measure temperature.

You might like to read the following to the class :

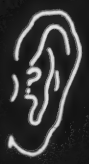
"It is quite hard for us in our nice warm country to imagine something very cold. The winter in Zimbabwe seems cold. Many of you will have seen white, icy frost on the ground on a wintry morning, but the frost always goes away by lunchtime. The coldest time is when the sun is not shining and ice is able to form.

However, in countries further from the Equator, it gets much, much colder. White frost and snow lie on the ground all day long, even if the sun shines for a short time. The ice cannot melt into water because the temperature of the ground is too low. What is the temperature at which the ice melts and the frost goes away? Do you know?

It has been decided that the temperature of melting ice will be called 0°C. It is NOT the coldest thing ever known, but it is very cold. There are some things (such as the ground below the frost) which get colder than 0°C and then we have to go"below zero" to explain how cold they are.

Listen carefully to the weather reports in July and August and you will sometimes hear that a very cold night is expected. Then the temperatures will be 'minus' - that is, less than zero. The coldest air temperature ever recorded in Zimbabwe was -11°C, in August 1972 at Matopos. This meant that the wir became very cold indeed and there was terrible frost which killed many plants.

Luckily we shall not be concerned with such cold temperatures! Our thermometer will be used for measuring temperatures above 0°C. Look at the scale again. We now know that the zero mark represents the temperature of melting ice. How do we read the scale? Inside the thermometer there is a liquid which you can see clearly. This liquid rises up the scale as things get hotter. Put your hand around the BULB and watch the liquid go up. That is because your hand is hotter than room temperature. It will probably to up to about 35°C if you hold it for long enough. Put the thermometer on the bench and watch the temperature go down again slowly.



How do we decide how big the scale must be? We know where to put the zero mark, but we still must decide how far apart to put the scale measurements. A man called CELSIUS decided that he would put the thermometer into the steam above boiling water and see how far the liquid went. He marked that point on the thermometer and called it "100°C". He then ruled off the space between the zero mark and the boiling water mark into 100 divisions, each of which he called one degree. Look at Diagram 2 and you will see what he did.

Celsius decided his boiling point of water would be 100°C. He did this experiment at sea level, but we in Zimbabwe are not by the sea. We are much higher up, and we find that our water does <u>not</u> boil at 100°C. Ours boils at about 96°C."

Ask the pupils to read the summary on page 14 of the study guide.

Now put Exercise 3, Questions 3 - 6 on the board so that the pupils can answer them in their books.

<u>Page 15 Experiment 7 Taking temperatures</u>

Tell the pupils that the temperature of "the air" and the temperature of "the room" are the same.

You will need a bucket of cold water as well as the one you prepared before.

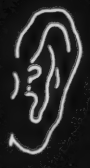
<u>Exercise 3</u>

1. My estimate of the water temperature is _____°C.
2. Teacher's reading is _____°C.
3. The thermometers in Diagram 3 read
   a) _____°C
   b) _____°C
4. Temperature of the air (room temperature) is _____°C.
5. Temperature of cold water in bucket is _____°C.
   Temperature of warm water in bucket is _____°C.
6. I can read the thermometer to the nearest _____°C.

Answers to Exercise 3 (for marking)

1. Any estimate between 37°C and 60°C
2. (about) 45°C
3. Thermometers read 20°C and 96°C
4. Check this for yourself by leaving the thermometer on the bench for about 10 minutes.
5. Temperatures of cold water and warm water are found by you, at the same time as the class measures them.
6. Error in thermometer (eyes cannot read better than) about ½°C. Therefore answers are accurate to the nearest ½°C.

Page 15 Another form of thermometer



You will have noticed that we have also included in the teacher's kit a different kind of thermometer. This Dial Thermometer is a much stronger instrument than the mercury thermometer which the pupils use. Unfortunately it is too expensive to supply for each pupil pair!

It can be used to measure the temperature of the water in the bucket and in any other experiments where the pupils use the mercury in glass thermometer. You might like to use both the mercury in glass thermometer and the dial thermometer to measure the temperature of the water in the bucket. Both kinds of thermometer need a little time to show a steady reading

Page 16 Measurement : Mass

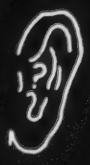
Experiment 8 Estimating masses

You will need : water

ASK THE PUPILS TO KEEP THEIR BOTTLE FULL OF WATER WHEN THEY HAVE COMPLETED THE EXPERIMENT.

Then they can answer Exercise 4, Question 1.

The complete Exercise 4 may be found on Page 19 of this guide.



Page 17 The Balance

The main things that you could point out to the pupils are :-

The maximum possible mass that can be measured on the balance.

The meaning of the large divisions and numbers.

The meaning of the smallest divisions.

Perhaps you could find the mass of a few articles such as the boiling tin, the conical flask etc. to show them how the balance is used.

Then ask them to answer Question 2 in this exercise.

Page 17. Experiment 9 Masses on a balance

You will need : your empty bottle
some soil

Once the pupils have found their bottles (one still full of water) they should fill their second one with soil. Both the bottle of water and the bottle of soil should have their caps on.

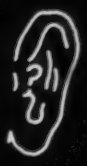
Each pair of pupils should then take turns to find the mass of

1) Your empty bottle
2) Their bottle full of water
3) Their bottle full of soil

They can then answer Exercise 4, Question 3, Parts (a) to (e).

Page 17 Ideas from the teacher

The pupils will have discovered by experiment that the soil has a bigger mass than the water. They will probably tell you that this is because it is heavier! This is really true, but you could ask them how they knew it is heavier. Don't go too deeply into this - just find out a bit about their ideas. You could perhaps suggest the idea of a quantity of something (such as soil) having more mass than the same quantity of another thing (air, or water!) and arrive at a general idea of density in this way.



Pupils may notice that they get different answers for the mass of soil in their bottles. This will probably be caused by different amounts of soil which may be packed loosely or tightly in the bottle. Discussing these differences will also help the pupils to arrive at a general idea of density.

Page 18 Experiment 10 Constructing a balance

This is not a difficult experiment but it is very long to read and carry out. Your pupils will need much encouragement and praise from you - indeed they deserve praise if they succeed in making it because it is quite a skilled thing to do.

You will need : paper clips (5 per pair of pupils)
straw (1 per pair) prepared by you ahead of time by cutting a V-shaped piece out of one end of the straw as in Diagram 4
pins (2 per pair)
scissors
extra paper, prepared by you ahead of time as follows:-
For each pair of pupils, cut a piece of blank paper measuring about 20 cm by 7 cm. Fairly stiff paper (such as the kind the pages of this book are made of) is best, but any kind will do.

P

Important note :-

1) If you can borrow extra pairs of scissors from someone, the time to do Stage 1 will be much less. Each pair needs to use scissors so the more you have, the better.

2) If you can gather old matchboxes (the class could be asked to collect them well in advance of this lesson) then they need not damage the boxes in their basic kits.

Page 20 Paragraph 1

Please make sure that your pupils use your strip of paper for the scale. They should fold it in half lengthwise to make a narrow strip, as shown in Diagram 4. When they put their little paper masses on the straw, it should swing freely at all times.

When they finally start to find the mass of the pin, they should try to keep the pin as near to the cut end of the straw as they can. It should not slip down inside the straw.

They can then answer Exercise 4, Question 4.

Exercise 4

1. Put these in order of mass. Start with the most massive, and finish with the least massive.

   brick, lorry, empty bottle, bottle with water, match, desk, your teacher!

   Most massive : 1.
   2.
   3.
   4.
   5.
   6.
   Least massive 7.

2. The heaviest mass our balance can measure is _____kg, that is, _____g.
   The smallest mass (one small division) it can measure is _____g.
   The error (the best the eye can see) in the balance is about half a division. This represents _____g.
3. You had three bottles. One was empty, one was full of water and the last was full of soil. All the empty bottles have the same mass.
   a) Which one had the biggest mass? _____
      It's mass was _____g.
   b) Which one had the second biggest mass? _____
      It's mass was _____g.
   c) Which one had the smallest mass? _____
      It's mass was _____g.
   d) Therefore the mass of soil was _____g.
   e) Therefore the mass of water was _____g.
4. a) The mass of the pin was _____g.
   b) My small balance can measure from _____ g to _____g.

Answers to Exercise 4 (for marking purposes)

1. Most massive :- 1. lorry
   2. desk
   3. teacher
   4. brick
   5. bottle of water
   6. empty bottle
   Least massive 7. match
   Of course, if you are very big (2) and (3) might be the other way around!
2. Observed by you
3. a) bottle and soil (mass measured by pupils)
   b) bottle and water (mass measured by pupils)
   (pupils may not get the same answers for these)
   c) empty bottle (mass measured by pupils)
   d) mass of soil = mass of (a) minus mass of (c)
   e) mass of water = mass of (b) minus mass of (c)
4. a) mass of pins measured by pupils
   b) range of balance is from 0,01 to 0,1g.

Page 21 Measurement : Time

P lease show the clock to the pupils and point out the sweep second hand.

Page 21 Experiment 11 Estimating a minute

Pupils can do this as many times as you feel necessary.

At the end of Experiment 11, please put Exercise 5, Question 1 on the board. The complete Exercise 5 is on Page 22 of this guide.

Page 22 Experiment 12

A timing exercise

This is quite easy to do.

You should note the exact time of starting in minutes and seconds and tell the pupils who are timing the runners. They can make a note of this in their books (Exercise 5, Question 2) and note the return time also. They can then calculate the time taken to run.

Exercise 5

Question 1 (a) My "one minute" call came after _____ seconds the first time.
Second estimate was _____ sec.
Third estimate was _____ sec.
etc.

(b) My partner's call came after _____ sec. the first time.
Second estimate was _____ sec.
Third was _____ sec.
etc.

Question 2 (a) I started running at _____ minutes _____ sec.
I finished running at _____ minutes _____ sec.
I took _____ min _____ sec to run.

(b) My partner started running at _____ minutes _____ sec.
My partner finished running at _____ minutes _____ sec.
Time taken was _____ min _____ sec.
I/my partner is faster?!!!!!

Question 3 I think I can read the clock to the nearest _____ second. This is my error.

Answers : There are no"right"answers to this exercise.

Page 23 Measurement : Volume

Experiment 13 : to calibrate the beaker from the pupil basic kit

You will need : water

The students should have no trouble with this experiment. The only difficulty might be in marking the beaker with a pen - it is a rather slippery surface to mark. Nevertheless they should succeed. A more permanent way to mark the beaker would be to scratch the marks with a sharp point and then make pen marks in the scratches. They could do this later if you wish.

Page 24 A big glass measuring instrument

Main idea : the pupils should understand the measurement of volumes using a MEASURING CYLINDER. Please allow them to look at the ones in your apparatus kit.

To explain their use, you might like to read the following :-

"The measuring cylinder is similar to your graduated beaker, only it it is bigger. The scale is marked on the side of the cylinder. At the top it says "cm³". The scale is divided into 100 divisions of 1 cubic centimetre each. Each ten centimetre cubed division is shown as ten, twenty, thirty etc.

The most important point about using this instrument is that the eye should always be level with the liquid being measured. Holding the measuring cylinder crooked results in a bad measurement. It should always be on a level with the eye".

Diagram 1.13 on page 9 of "Science for the Seventies" may be helpful.

After reading the above text, please give the class the beans.

Page 24

You need : fifteen beans per pair of pupils

Ask one of the pair to come up with a plastic cup and get the bean seeds from you.

Please put Exercise 6, Question 1 on the board now.

The complete Exercise 6 is on page 24 of this teacher's guide.

Page 24 Experiment 14 To find the volume of 15 beans

The pupils can finish Exercise 6 when they have completed this experiment.

Exercise 6

1. My estimate of the volume of a single bean is _____ml. (_____cm^3)
2. When I dropped the beans into the water, the water level rose to _____ml. (_____cm^3)
3. 25 cm^3 of this volume was water. Therefore the rest was the volume of the beans.
   Therefore the volume of fifteen beans was _____ml (_____cm^3)
4. Therefore the volume of one bean was _____ml (_____cm^3)
5. I think my measurement of the water levels in the beaker was correct to the nearest _____ml (_____cm^3)

Answers for marking

1. Any estimate provided it is small
2. Should rise to about 40 cm^3
3. Should be about 15 cm^3
4. Should be about 1 cm^3
5. This may vary, but probably pupils feel they can measure to the nearest ½ division on their beaker (2,5 cm^3). They may feel they can do better than this - use your judgment here!

Page 25 Exercise 7

Answers to "How much do you know?"

1. metre rule
   metre (m)
2. thermometer
   degrees Celsius (°C)
3. mass
   kilogram (Kg)
4. time
   second (sec)
5. volume
   cubic centimetre (cm^3) or millilitre (ml)
   - allow either of these

Part 2

Page 26 Experiment 15 Observations made when substances are mixed

This requires a lot of preparation ahead of time on your part. However it is great fun for the pupils and is a very important introduction to later practical work in chemistry.

In the experiment pupils are going to mix three pairs of substances which you have prepared. The main purpose of mixing these substances is to practise observing what happens.

You will need to explain to the pupils that they are preparing mixtures of the following three pairs of substances :

Mixture A	Substance 1 and Substance 2
Mixture B	Substance 3 and Substance 4
Mixture C	Substance 5 and Substance 6

Organisation of the class will be very important if this experiment is to be successful. We suggest each mixture is made in turn, and you give the following instructions for each mixture.

For example: for Mixture "A" (Substances 1 and 2)

Step 1 : Ask one from each pair to come and collect 5 ml of Substance 1 in a plastic bottle from the basic kit.

Step 2 : Ask the other one from each pair to come and collect 5 ml of Substance 2 in the other plastic bottle from the basic kit.

Step 3 : Pour the contents of each bottle into the graduated beaker.

Step 4 : Observe everything that happens.

Step 5 : Write down everything they observed.

Step 6 : Wash out beaker and bottles VERY WELL with water.

Repeat these instructions for Mixture "B" (Substances 3 and and 4) and Mixture "C" (Substances 5 and 6)

You will need :

1 . Ammonia solution (ammonium hydroxide) in the given bottle labelled SUBSTANCE 1.

2. Copper sulphate solution labelled SUBSTANCE 2.
This is made by you as follows :-
Into a clean conical flask put 5 spatulas copper sulphate. Add 140 ml water. Stir until all dissolves. This may take some time. When it has all dissolved, pour it into two boiling tubes. Label them SUBSTANCE 2 and stand them in your boiling tin. Wash the flask and spatula well. DRY the SPATULA THOROUGHLY.

3. Sodium hydroxide solution labelled SUBSTANCE 3, made by you as follows :-
Into a clean conical flask put 4 spatulas sodium hydroxide pellets. Add 140 ml water and stir till dissolved. (CAUTION : handle sodium hydroxide carefully as before). Keep this in the flask labelled SUBSTANCE 3. Wash and dry the spatula.

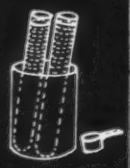
4. Ammonium dichromate solution labelled SUBSTANCE 4.
For this solution, put 5 spatulas ammonium dichromate into another (clean!) conical flask. Add 140 ml water and stir till dissolved. Pour this into boiling tubes as you did for the copper sulphate. Label them SUBSTANCE 4 and stand in another boiling tin (borrowed from a pupil). Wash the flask and spatula well. DRY THE SPATULA.

5. Sodium carbonate solution labelled SUBSTANCE 5.
Put 6 spatulas sodium carbonate into a clean flask. Add 140 ml water and stir well until dissolved. Once again, put this solution into boiling tubes. Label SUBSTANCE 5 and stand in a boiling tin.

6. Diluted acetic (ethanoic) acid labelled SUBSTANCE 6.
Keep this in the bottle provided.

Please turn over

Now borrow five 5 ml measures from pupils.
Arrange the solutions as in the diagram below :-

					
SUBSTANCE 1 Pupils should use your 5 ml measure to measure out substance 1.	SUBSTANCE 2 Borrow a 5 ml measure to use ONLY for substance 2. Pupils can pour this solution out for themselves.	SUBSTANCE 3 Pupils must use their dropper to take one dropper full of substance 3. CAUTION : Do not spill.	SUBSTANCE 4 Borrow a 5 ml measure to use ONLY for substance 4 Pupils can pour this solution out for themselves.	SUBSTANCE 5 Borrow a 5 ml measure to use ONLY for substance 5. Pupils can pour this solution out for themselves.	SUBSTANCE 6 Borrow a 5 ml measure to use for substance 6 Pupils can pour this solution out for themselves.

They should write up the experiment as instructed, under the heading "Exercise for Experiment 15".

They should include the following observations

Substance (1) + Substance (2) : given in study guide as an example
Substance (3) + Substance (4) : Ammonia smell produced
Substance (5) + Substance (6) : Fizzing noise and bubbles produced

Observations about solids forming (or not forming) are also good ; plus anything else at all that they can see, hear, feel or smell. The more they write, the better!

Page 27 Experiment 16 Finding the melting point of naphthalene

You will need : Naphthalene
water
your spatula/stirrer
the clock
thermometers (one pair pair of pupils)
aluminium foil (one piece per pair of pupils) This should measure roughly 15 cm x 10 cm and should be cut up by you ahead of time. Pupils can collect the foil when they come up for the thermometer. They fold it in half to make a piece 7½ x 10 cm and use this to make a small cup.

When the pupils have prepared their foil cups, they can bring them to you. Please hold the cup over the naphthalene bottle as it is a little awkward to put the 5 spatulas naphthalene into the cup and you may spill some.

WARN the pupils not to put the naphthalene near the burner flame : it will catch fire easily. If by some chance an accident happens and someone's naphthalene DOES catch fire, then you should go up quickly and blow it out with one hard blow. It will go out quickly.

I f the pupils find that the temperature of the naphthalene does NOT reach 80°C, they should heat the water to boiling again using their burner UNDER YOUR CLOSE SUPERVISION. The shorter the time that the burners are alight, the better. The same applies to the later instruction (Page 29) about removing the thermometer from the solid naphthalene. Keep a close watch at all times!

For this experiment, the exercise to be done is included in the study guide (Page 29).

Page 30 Experiment 17 : To measure a pulse rate

P lease show the pupils where to find their pulse beating in their wrist.

Please note that there is a small error in the text : the Exercise for this experiment is NOT Exercise 10, but is "Exercise for Experiment 17", as shown below. Please put the exercise on the board.

Exercise for Experiment 17

1 . My partner's pulse measured _____beats in one minute.

(Second reading was _____beats/min.)

2. My own pulse measured _____beats/min.
(Second reading was _____beats/min.)

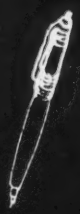
3. After 30 secs running on the spot, my partner's pulse measured _____beats/min.

4. After 30 secs running on the spot my own pulse measured _____beats/min.

From these measurements I can decide that _____

_____

_____



Answers (for marking purposes)

You will see a large range of results here. Please assure the pupils that no one had a "better" rate than others! They will find, however that their pulse speeds up after exercise. Again, some will speed up more than others!

Page 31. Experiment 18 Matching sounds

Sometimes you may find a pupil who cannot distinguish between two notes which are close together. Such a pupil will find this exercise very difficult.

You will need : elastic bands (one per pair of pupils)

After carrying out this experiment, pupils can answer the following exercise.

Exercise for Experiment 18

When the sounds matched, the length of ruler that stuck out from the desk was _____cm.

Answer for marking:-

There is, once again, no "correct" answer. Pupils should, however, try to read their rulers to the nearest millmetre

Page 32

Experiment 19 To measure the volume of a piece of polystyrene.

You will need : small stones (one per pair of pupils)

These are to form the small "weights" mentioned in the study guide. You could collect these ahead of time, or ask the pupils to find one each. They should be about 1 cm across.

Thread
Scissors } available on your desk
water
polystyrene (one piece per pair of pupils,
(or anything such as wood, which floats!)
The piece should be about 1 cm each way.

Try not to tell the pupils too much here; they should be able to think it out for themselves that they should tie the polystyrene to the stone to pull it under the water. If they can't work it out, try to give them the least possible help.

Put the exercise on the board when they have completed the experiment.

Exercise for Experiment 19

1 . Volume of water in beaker = ml
Volume of water + stone = ml
Therefore volume of stone = ml
Volume of water + stone + polystyrene = ml
Therefore volume of polystyrene = ml

Answers : As measured by the pupils

Page 32. Experiment 20 To find the mass of 25 cm^3 of water

You will need : balance
water

Once again don't give too much away. Just make sure that no water spills out of their beakers on to the balance pan while they are weighing.

Perhaps you could also point out that the empty beaker should be quite dry when they find its mass.

Put the exercise for the experiment on the board when all have finished working.

Exercise for Experiment 20

1 . Mass of empty beaker = g.
2. Mass of empty beaker + water = g.
3. Therefore mass of water = g.

Answers : As you know, 25 cm^3 of water should have a mass of 25 g but their calibration may not be exact. Allow a range of 20 - 30 g as being correct.

Page 33 Experiment 21 To find out which is hotter : the pupil's methylated spirit burner flame or your gas flame

They will need : your Labgaz burner
water
thermometers

In this experiment, the whole class cannot use your Labgaz burner at the same time. Either they will have to take turns or (probably the best) they can ask one of the class to heat up water over your burner while the rest compare the rate of heating the same quantity of water over their burners.

Don't tell them this straight away! Ask them a few questions. The sort of questions you should ask them are on page 12 of "Science for the Seventies" (first column). This book will also give you some hints on how the children might solve this problem, but let them think it out!

Exercise for Experiment 21

Ask the pupils to write a report of this experiment under the following headings :-

What I did
What I noticed
What I thought about our methylated spirit burners when compared with the teacher's gas burner (my conclusion)

W e would like you to discuss the results the pupils obtain for their different burners. This will help them to realise that there are other factors involved in the heating of the water eg. different size wicks, different size flames, wind.

Page 33 Experiment 22 To find the mass of a bean

You will need : the balance
about 25 beans

Here the pupils will have to take turns to find the mass of some beans. The number taken does not really matter - leave the decision up to them but encourage them to take a fairly large number. The error in weighing very few beans is quite large, so at least 20 should be used. They can weigh these directly on the balance, or in a beaker on the balance. Leave the decision to them. When all have finished working, put the following exercise on the blackboard.

Exercise for Experiment 22

1 . Number of beans taken = ____
2. Mass of beans = _____ g.
3. Therefore mass of one bean = ____ g.

Answers (for marking)

As measured by the pupils. They should read the balance as accurately as possible.

Page 33 Experiment 23 To find the thickness of a page of the study guide

Here the pupils should have no difficulty. If they are having problems, ask them to count the pages, and think back to the bean experiments. They may then guess that they should measure the thickness of the whole book, and divide by the number of pages.

When all have finished working, put the exercise for Experiment 23 on the board.

Exercise for Experiment 23

1. Thickness of book = about 6 mm
2. Number of pages = 24
3. Therefore thickness of one page = about 0,25 mm

Answers (for marking)

1. As measured by pupils. Encourage them to read to the nearest mm (or half mm)
2. Let them count the 24 pages for themselves.
3. This will of course be a very small length. They should record their answers to the second decimal place.

Page 34 More interesting problems

There is a very good introduction to problems of this kind in "Science for the Seventies", page 17 paragraph 1.16 - The Black Box. You might like to read and explain this paragraph for the pupils.

We suggest you introduce a change in the organisation of practical work for these problems : set out all the Experiments 24, 25, 26 and 27 at the same time in different places around the class room. Divide the class into four groups and let each group work on one experiment for ten minutes. Change the groups around after each ten minute period until all the groups have tried all the problems.

Experiment 24 Attracting other substances

Please put out together
- some magnets
- the contents of a complete basic kit

If the pupils cannot think what to do ask them to hold their magnets near to each of the items in the basic kit. Probably they will not be puzzled about what to do and will not need your help here.

Experiment 25 A swinging weight

You will need : a piece of thread 60 cm long
a stone about 2 cm in diameter

Tie the stone securely to the thread and tie the thread to your stand triangle so that the pendulum you have made hangs freely over the edge of your desk. You may have to place a weight on the base of the stand to stop it tipping over.

Remind the pupils that a full swing is across and back again. To measure one is too short a time. They should measure many swings and divide the time by the number of swings to arrive at an answer.

Experiments 26 and 27 Two boxes

Into your basic kit box put a torch battery and a match box with about 15 matches in it and close the box tightly.
Into a second box (borrowed from a pupil) put one of the little bottles from the basic kit half full of water, (with the lid on!) and close the box.
The pupils should have no idea what is in the box. Tell them nothing!

Exercise for "More interesting problems"

After completing "Test" "Observation" as instructed, the pupils could complete the following :-

1. I discovered that some items were attracted to the MAGNET and some were not. I can group them into

Items attracted	Items not attracted

2. The length of time the pendulum took for one swing across and back was _____ sec.
3. I think the first box contained _____

   I think the second box contained _____

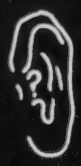
Answers (for marking)

1. They should find that all iron items are attracted.
2. Should be about 2 sec.
3. There is no "right ot wrong" answer to this. If they have made an intelligent guess, it should be marked correctly. Please use your judgment.

Part 3 What to do with results

Pages 35 - 37 Making a histogram

Please read these pages aloud with the pupils. Construction of a histogram is a very difficult concept and it will be to your credit if they understand it well! The words "vertical axis" and "horizontal axis" might not be familiar to them. Please explain their meaning carefully.



Page 38 Constructing the class histogram

Ask the pupils to look back at Exercise 2, and to call out their guesses (Question 1) to you. Put all the guesses on the board, and then group them in the following way :

1. Find the lowest guess.
   Suppose it is 6,4 m.
   Then make your first group from 6,0 to 6,5 m.
   Make the next group 6,5 to 7,0 m and so on until the last group is reached (the highest guess).
   It does not matter how many groups you have. The division of 0,5 m for each group is the most convenient to choose, but you may prefer a smaller division. It is up to you!

   Then make a table on the board of

Group	Number of children who guessed in this group

The pupils will now be ready to construct the histogram. If they have graph paper, so much the better, but they can use the lines of exercise book paper if necessary. The will then need a ruler to mark equal divisions. It is not possible to predict the pattern that your class will get. If it is not a normal pattern, you should be able to say that the class "tends to guess too high" or "tends to guess too low" or some such thing. It is up to you!

Page 39 How much do you know?

This is the final exercise that the pupils will do in this unit. Hints for marking are :-

1. Limits of the thermometer are the maximum and minimum readings marked on the scale.

2 - 4. As carried out in the preceding experiments.

Page 40 Summary

Please read this aloud with the pupils very carefully. The pupils could copy this summary into their exercise books.

When they have finished the unit, ask the pupils to look back at Page 1 of their study guides. They can now read through "Aims" of the unit and will find that they can understand them all! If there is any "aim" that they feel is not fully understood, please go over that section again.

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